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ABSTRACT

This study examined whether inclusion of cognitively guided instruction (CGI) in a mathematics methods course for 34 undergraduate preservice teachers at the University of North Carolina at Greensboro would improve their teaching performance, compared to controls. The Beliefs Survey, with four subscales (Role of the Learner, Relationship between Skills and Understanding, Sequencing of Topics, and Role of the Teacher) was administered four times. The mathematics methods course occurred between the second and third administrations, and student teaching occurred between the third and fourth administrations. The survey revealed that preservice teachers in both cohorts changed beliefs to a more constructivist orientation to teaching mathematics during their professional program of study. In both cohorts, the greatest change in beliefs occurred during the semester in which the mathematics methods course was taught, suggesting that dealing explicitly with mathematics pedagogy influences preservice teachers' thinking about teaching and learning mathematics. The beliefs of the CGI cohort continued to change fairly dramatically during the student teaching semester while the beliefs of the non-CGI cohort did not. In response to open-ended questions, preservice teachers acknowledged the need for teachers to know what children were thinking. There were few suggestions from either cohort on how CGI should be actualized in instruction. Implications for teacher preparation are offered. (Contains 28 references.) (JDD)

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Changes in Undergraduate Preservice Teachers' Beliefs During an Elementary Teacher-Certification Program

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What teachers believe about teaching and learning mathematics significantly affects the form and type of instruction they deliver (Clark & Peterson, 1986; Dougherty, 1990; Grant, 1984; Marks, 1987; Romberg & Carpenter, 1986; Thompson, 1984). Similarly, if teachers' beliefs are incompatible with the underlying philosophy and materials of a curriculum, full implementation of that curriculum may be unlikely.

The current call for reform in mathematics education (National Council of Teachers of Mathematics [NCTM], 1989, 1991; National Research Council, 1989) has been shaped by a constructivist approach to teaching and learning mathematics (Cobb & Steffe, 1983; von Glaserfeld & Steffe, 1991). But, in order for this reform to be implemented fully, it appears that teachers would need to believe that (a) their role is to be actively engaged in planning and guiding instruction based on students' understanding and performance and (b) students' roles involve active engagement in solving a variety of meaningful and relevant problems, communicating mathematically, reasoning, and making mathematical connections. As Thompson (1992) indicated, advancing the reform effort in mathematics education requires preparing teachers who will implement instructional plans through a constructivist approach to teaching and learning and also will serve as change agents to help other teachers internalize that philosophy.

Many classroom teachers, however, are products of teacher-preparation programs that focused on ways to help students develop skills by mastering mathematical concepts and procedures which are demonstrated or modeled by the teacher. In turn, many preservice teachers, who are products of these teachers' classrooms, believe either that teaching is telling (Vosniadou & Brewer, 1987) or that teaching is the things that a teacher does and says (Reynolds, 1992). A need exists, therefore, to determine ways in which teacher-preparation programs can advance the reform efforts in mathematics education by preparing future teachers whose beliefs are aligned with the current curriculum perspective.

Researchers have long acknowledged that beliefs are difficult to change whenever individuals are satisfied with their current beliefs, intelligible and useful alternatives do not exist, or alternative beliefs are not linked to previous or existing conceptions (Posner, Strike, Hewson, & Gertzog, 1982). Precisely how these findings might apply to preservice teachers, however, is unclear. The literature addressing changes in preservice teachers' beliefs across their program of study is limited, recent studies involving direct interventions to challenge preservice teachers' beliefs have produced mixed results, and studies focusing on useful alternatives to existing beliefs have been conducted mainly with inservice rather than preservice teachers.

Changes in Preservice Teachers' Beliefs

Early studies of preservice teachers' beliefs focused on changes influenced either by the overall program of study or by one specific component; inconsistent conclusions often resulted. Collier (1972) found that preservice teachers at the beginning of their program of study believed that mathematics

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teaching was teacher-directed, memorizing facts was important, and students needed to find single solutions to problems. By the conclusion of their program, however, their views shifted toward the importance of student discovery, trial-and-error strategies, and creative thinking in mathematics education. Shirk (1973) studied the effect of the mathematics methods course only on preservice teachers' beliefs and concluded that elementary preservice teachers' conceptions were not altered significantly as a result of the course. It is not clear, however, how the underlying philosophy of Collier's program might have differed from the philosophy of Shirk's methods course. More recently, Zeichner and Liston (1987) found that preservice teachers' beliefs were not significantly altered as a result of student teaching. Rather than changing their perspectives, preservice teachers became more skillful in expressing and implementing their points of view.

Brousseau and Freeman (1988) concluded that because teacher-preparation programs generally have not challenged students' initial beliefs, preservice teachers often conclude their program of study without examining their own thinking and perspective of mathematics education. Recent studies have addressed this deficiency by explicitly designing program components that challenge preservice teachers' beliefs. These studies, however, also have produced mixed findings. Schram, Wilcox, Lanier, and Lappan (1988) reported changes in preservice elementary teachers' mathematical conceptions as a result of their participation in the first of three innovative mathematics courses that emphasized conceptual development, group work, and problem-solving activities. The 10-week course, which focused on numbers and number theory, provided students with ongoing opportunities to collectively and cooperatively learn ways to make sense of mathematics, build models as a means of understanding mathematical situations, and invent procedures to solve problems. The researchers concluded that this single course was successful in challenging preservice teachers' beliefs about what it means to know mathematics. However, at least half of the students continued to believe that the type of instruction modeled in the course was unrealistic for elementary classrooms. As part of this larger study, Schram and Wilcox (1988) examined belief changes based on three levels that reflected different orientations to teaching and learning mathematics. They found that one of their two case-study students changed his original views about what it means to know mathematics based on his experiences in the course. The other student, however, modified the new experiences and conceptions to fit her existing set of beliefs. The latter finding was supported by McDiarmid (1990), who found that many preservice teachers resisted change even when a course was designed specifically to challenge their underlying beliefs about mathematics education.

It would seem, then, that isolated experiences, even those specifically designed to challenge preservice teachers' beliefs, are likely to meet with mixed results. Perhaps linkages are needed, not only among components of work completed on the university site but also between campus-based activities and field experiences in schools. Techniques for creation of these linkages might be gleaned from studies of changes in beliefs of inservice teachers.

Carpenter, Fennema, Peterson, Chiang, and Loef (1989) and Fennema, Carpenter, and Loef (1993) found that inservice teachers who participated in a professional-development program on cognitively guided instruction (CGI) changed their beliefs about teaching and learning mathematics and, subsequently, the instructional decisions they made during instruction. As a result, students in these teachers' classrooms spent more time finding and sharing alternative solution strategies to problems and less time in rote and skill development activities. These changes in teacher and student behaviors

meet the call for reform in mathematics education. Including CGI in the mathematics methods course and related field experiences may hold promise for effecting similar changes among preservice teachers.

Cognitively Guided Instruction

Cognitively guided instruction (CGI) is an approach to teaching mathematics in which children's knowledge is central to instructional decision making. Teachers use research-based knowledge about children's mathematical thinking to help them learn specifics about individual students and then adjust the level of content to match individual students' performance levels. CGI is not a prescriptive procedure; rather, teachers use CGI in a manner that fits their own teaching styles, knowledge base, beliefs, and students. Yet, classrooms of CGI teachers have several similarities. Children spend most of their mathematics instruction time solving a large variety of problems by creating their own solutions rather than following a set of procedures provided by an outside source (e.g., teacher or textbook); as part of this process, students spend considerable time sharing solution strategies. That is, students listen to and learn from each other. The teacher and students ask questions until they have developed an understanding of the problem solutions. Children are perceived by the teacher as being in charge of their own learning; teachers facilitate this learning during the day through relevant and meaningful problems and the integration of mathematics into other learning activities.

Working within well-defined taxonomies of problem types and children's solution strategies for arithmetic operations, teachers are able to validate research results about children's thinking and to use that validated information to develop techniques for adjusting instruction so that it is responsive to the needs of children in the classroom. This validation process by each teacher seems to be one of the critical components of CGI inservice. From our observations of inservice teachers who are learning to use CGI, it appears that validation of the extensive research on children's thinking about operations also prepares teachers to extend their personal knowledge of their students' thinking into other mathematics (i.e., fractions and geometry), even though research about children's thinking in these areas is less clear.

The "mathematics" of CGI can in part be defined as "more with less." Rather than focusing on individual "bits" of mathematical knowledge, the mathematical emphasis of CGI is on the four aspects of mathematics that are common standards across all grades: (a) problem solving, (b) communication, (c) reasoning, and (d) connections. CGI teachers stress the need for students to develop "mathematical power" through mastery of techniques for doing mathematics as it impacts mathematical understanding. Activities are sequenced in a way that is consistent with the sequence in which concepts and skills develop naturally in children. Instruction is based on children's cognitions; children are not asked to do things that do not have meaning for them.

The major organizing activity in CGI classrooms is problem solving, with children's understanding being assessed through their reported solutions to problems of many types. Thus, the teacher has to have extensive pedagogical content knowledge, including knowledge of mathematics, instructional techniques, and children's cognitions. The teacher's role is to assess students' thinking and then to provide appropriate instruction that helps children progress to more mature mental functioning through extensive opportunities to engage actively in appropriate and relevant problem-solving activities.

Effects of CGI on Students and Teachers

Carpenter et al. (1989) found that giving teachers access to research-based knowledge about students' thinking and problem solving, through preparation in using CGI, significantly affected students' achievement. Significant positive correlations were also found between CGI and students' mathematics problem solving achievement (Peterson et al., 1989), ability to solve complex addition and subtraction word problems (Fennema et al., 1989), and level of recall of number facts (Carpenter et al., 1989).

Considerable evidence also exists to suggest that with appropriate support, primary-grade teachers can learn about children's mathematical thinking and can learn to use this knowledge to improve instruction; that is, they can learn to use CGI (e.g., Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Fennema, Carpenter, & Peterson, 1989; Fennema, Franke, Carpenter, & Carey, 1993; Peterson, Fennema, Carpenter, & Loef, 1989). In particular, our recent experiences working with inservice teachers over three years as they learned to use CGI provides evidence of the changing concerns of teachers as they "grow into" use of CGI. Initial concerns of understanding the foundation of CGI were replaced by concerns about organizing mathematics instruction around problem solving, asking children to explain their solutions, and other related instructional strategies such as infusing mathematics across the curriculum. As teachers' competencies developed in these pedagogical areas, their concerns shifted to effective ways of planning instruction based on the data being gathered about each student's thinking. Comments from teachers' journals verify this sequence of changes:

> [As I first learned about CGI, I was] concerned about the problem types and giving them to the children and being able to listen to the children and what they were thinking. Also, [I was] concerned about the control of the students and how they listened to each other. [Then I became] concerned if I had accomplished any part of CGI with my students. ...[Now I] try to listen to what each child is thinking and better build on their knowledge so they can progress.
>
> Following the first summer ... my main concern was coordinating CGI with the [North Carolina] Standard Course of Study and meeting [standardized] testing successfully. ... [The second year] I focused more on having less problems, feeling less rushed, and permitting students more opportunities to write and share their own problems. ... [Now] instruction is more child centered, and my goal is to assess and record students' thinking through ongoing assessment.

Structure of Undergraduate Program at UNC Greensboro

The undergraduate elementary preservice teacher education program at the University of North Carolina at Greensboro (UNCG) was restructured in 1991 to incorporate professional development schools (PDSs). The PDS model (Holmes Group, 1990) involves a learning environment where all participants (i.e., students, inservice and preservice teachers, principals, and other school personnel) continue to learn. The basic premise is that schools dedicated to the education of all personnel will also be better places for students to learn. The PDS model also supports sustained experiences in classrooms that help preservice teachers integrate what they are learning about teaching with what they are observing, doing, and experiencing in classrooms (i.e., making connections between theoretical frameworks and practice). As a result of the partnership between the university and public schools, classroom teachers

serve as on-site teacher educators and are in a position to make significant contributions to planning, implementing, and evaluating changes in the teacher-preparation curriculum.

The PDS model was implemented at UNCG through the establishment of inquiry teams, each of which consists of a group of preservice teachers who take all their professional courses together as a cohort, on-site teacher educators, a university faculty member who serves as the team leader, and a doctoral student who assists the team leader and helps supervise in-school experiences. Two or three cohorts of undergraduate preservice teachers (approximately 30 students each) are enrolled each year, with each cohort assigned to two or three PDSs. The on-site teacher educators meet regularly with University faculty to plan the field experiences for the preservice teachers (e.g., observations, tutoring, small- and whole-class instruction, and individual assessment of children) and also model instructional activities for the various methods courses. As a result of the structure of the UNCG program, the on-site teacher educators come to know the undergraduates fairly well and are typically willing for undergraduates to try out a variety of instructional methods. Each cohort meets regularly with the team leader to debrief experiences; that is, the program focuses on reflective teaching, which is generally consistent with CGI.

Preservice teachers in the undergraduate cohorts are required to take a mathematics placement test at the beginning of their freshman year and to complete six semester hours of unspecified course work in the Department of Mathematics before their junior year. They complete the mathematics methods course during the fall semester of their senior year. In addition to 15 other semester hours of methods and introduction to teaching course work, 46 semester hours of liberal arts requirements, and a second major of 24 semester hours in arts of sciences, these students complete 9 semester hours of inquiry seminars which include ten hours per week of internship during both semesters of the junior year and the fall semester of the senior year. Their full-time student teaching experience is completed at one of the PDSs during the spring semester of the senior year.

Intervention

This study is part of a larger project (funded by the National Science Foundation) to investigate whether cognitively guided instruction (CGI) as described in the literature (e.g., Carpenter, Fennema, Peterson, Chiang, & Loef, 1989) can be incorporated effectively into undergraduate preservice teacher education programs. The project is documenting whether use of CGI will improve the teaching performance of beginning teachers, much as CGI has been documented to improve the performance of experienced teachers. The intervention in this study was the inclusion of CGI in the mathematics methods course for one of the two inquiry teams established in Fall 1991; CGI was not included in the mathematics methods course for the second team.

Subjects

Subjects were two cohorts of undergraduate preservice teachers. One cohort (CGI cohort; N=34) received instruction on CGI in the methods course, and one cohort (non-CGI cohort; N=34) did not. Other aspects of the two versions of the methods course (e.g., textbook, assignments, introduction to the Standards, use of manipulatives) were not identical, but they were comparable. The mathematics methods course was completed during the first semester (Fall 1992) of the senior year.

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Instrumentation

The Beliefs Survey (developed for earlier CGI research) was administered four times: August 1991, August 1992, January 1993, and May 1993. The mathematics methods course occurred between the second and third administrations, and student teaching occurred between the third and fourth administrations. The Beliefs Scale has four subscales: Role of the Learner, Relationship Between Skills and Understanding, Sequencing of Topics, and Role of the Teacher. Higher scores indicate beliefs that are more consistent with constructivism. Data on preservice teachers' beliefs were also collected for a randomly selected subset of preservice teachers in each group through responses to open-ended interview questions that addressed the teacher's role in mathematics education.

Results

Using two-sample t-tests, no differences existed between CGI and non-CGI cohorts on the Role of the Learner and the Role of Teacher subscales at any of the four administrations (Table 1). In August, 1992, at the beginning of the mathematics methods course, non-CGI preservice teachers scored significantly higher ($p<.01$) than CGI preservice teachers on the Skills and Understanding subscale and the Sequencing of Topics subscale; non-CGI preservice teachers had a more constructivist orientation than did CGI preservice teachers. Scores on the Skills and Understanding and Sequencing of Topics subscales, however, were essentially equal at the other three administrations. For the CGI cohort, the changes in mean scores were 2.6, 23.2, and 11.7 during consecutive administrations of the Beliefs Survey. For the non-CGI cohort, the changes were 10.2, 15.9, and 4.3. The scores on the first and fourth administrations were not statistically different between the cohorts. However, on each of the first three administrations, the non-CGI cohort scored higher, while on the fourth administration, the CGI cohort scored higher.

Insert Table 1 about here

CGI Cohort

Based on a repeated-measures analysis of variance and follow-up paired t-tests of scores at adjacent times for the CGI cohort, a significant overall time effect ($p<.0001$) was observed for all four subscales as determined by Wilks' Lambda and its associated F-statistic. Subscale means changed little from August 1991 to August 1992. However, there were significant increases in the means of all four subscales from August 1992 to January 1993 and again from January 1993 to May 1993.

Non-CGI Cohort

Based on a repeated-measures analyses of variance and follow-up paired t-tests of scores at adjacent times for the non-CGI cohort, a significant overall time effect ($p<.05$) was observed for all four subscales as determined by Wilks' Lambda and its associated F-statistic. From August 1991 to August 1992, there was a significant increase in the mean of Sequencing of Topics subscale, but there were no changes in the other three subscales. There were significant increases in means of all four subscales from August 1992 to January 1993. However, all subscales remained constant from January 1993 to May 1993.

Qualitative Findings

In response to the open ended questions, preservice teachers acknowledged the need for teachers to know mathematics content and to use manipulatives in teaching. There was some acknowledgment also of the need for teachers to know what children were thinking.

> [Using manipulatives] helps [students] see how it is done and [they] have an understanding of the relationship and not just something that they memorized for homework. *CGI Preservice Teacher*

> When they use manipulatives, I feel like that is an assessment because...I can walk around and see what they are doing and see if they really understand or if they are just playing. *CGI Preservice Teacher*

> Looking at their papers where they have drawn things ... tells me a lot about ... whether or not they understand what they are doing. *Non-CGI Preservice Teacher*

There were few suggestions from either cohort on how CGI should be actualized in instruction.

> [My role as a teacher is] to be, and I'm still learning how to do this, a facilitator -- not tell them what they have to do. ... It is hard to adjust to being like that. I want them to figure out things for themselves and maybe things will arrive that I haven't even planned on yet. *CGI Preservice Teacher*

> I'm asking them to find different ways and let them figure it out on their own. *CGI Preservice Teacher*

> There is such a broad range of abilities that it would be very hard to just say, "Okay, this is how we are going to do it." Some of them don't need any assistance. Some of them need more assistance than others. ... I would like them to think about it, ... and get it from my assistance and not my direction. *CGI Preservice Teacher*

> In the beginning I was more like, "Okay, this is this and this is this." I would just tell them if I wanted them to know, and now ... I'm learning a little bit more and more to ask them questions and let them tell me what they don't understand and if they have any questions. *Non-CGI Preservice Teacher*

> We try to relate math problems and ... integrate everything ...[use] some isolated facts ... in some kind of story concept. *Non-CGI Preservice Teacher*

> I changed [my plans] with each individual ... if they didn't understand but I didn't change the [planned] lesson. *Non-CGI Preservice Teacher*

Case Studies. Detailed case studies currently are being developed for 12 members of the CGI cohort. Based on findings from preliminary qualitative analyses of two of these case studies (i.e., Cindy, who completed student teaching with a CGI on-site teacher educator, and Marsha, who completed student teaching with a non-CGI on-site teacher educator), differences appear

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to exist in the degree to which the preservice teachers implemented CGI in their student-teaching classrooms and the way in which their beliefs changed across the program of study.

Cindy's and Marsha's scores on the four administrations of the Beliefs Scale are presented in Table 2. As illustrated by their respective total scores, Cindy had a more constructivist orientation to teaching and learning mathematics at the beginning of her program of study than did Marsha. As they proceeded through their teacher-preparation program, each continued to modify their beliefs to be more constructivist in orientation, but differences existed in the ways their beliefs changed.

Insert Table 2 About Here

Their beliefs concerning the role of the learner changed somewhat similarly across the four administrations of the Beliefs Scale with the greatest change occurring during the mathematics methods course. Cindy's beliefs about skills and understanding changed the most during the semester when she was enrolled in the mathematics methods course, whereas Marsha's beliefs in this area seemed to be affected most by experiences during the first year of the program. Concerning their beliefs about the sequencing of topics and the role of the teacher, Cindy's changed very little across the four administrations whereas Marsha's changed as a result of the mathematics methods course. Finally, a difference existed in the change in the total beliefs score for each. Cindy's overall beliefs about teaching and learning mathematics changed substantially as a result of the methods course and continued to change in a more constructivist direction during student teaching. Marsha also made a substantial change in her overall beliefs as a result of the mathematics methods course, but there was little change in her beliefs as a result of the student-teaching experience.

Cindy. By the conclusion of her program of study, Cindy had acquired the basic rudiments of a CGI philosophy and was beginning to demonstrate an ability to function between levels 2 and 3 of the Teachers' Level of Development framework (Loef & Fennema, 1992). She believed that children could solve problems without instruction and the knowledge she gained from listening to children talking about their thinking could help her make informed decisions. The degree to which she used this information in planning instruction, however, remains unclear. During student teaching she involved her students in a variety of problem-solving activities that extended beyond the problem types, but it appears that the North Carolina Standard Course of Study remained as a significant influence on her instructional planning. Assessment of students' thinking appeared to be ongoing in mathematics lessons; she did not conduct individual interviews, but she did use students' journal entries as a form of assessment. Cindy was encouraged by the on-site teacher educator to gather information about students' thinking and to use that information to adapt instruction. Also, prior to assuming full responsibility for planning and implementing instruction, Cindy saw CGI being implemented in regular mathematics instruction.

Marsha. At the conclusion of her program of study, Marsha seemed to understand the basic principles of CGI, but the overall implementation of this approach in her teaching was limited. During student teaching, she provided opportunities for children to solve problems and to share their thinking, but she did not seem to use what she was hearing in an integrated way. Questions asked at the beginning of the student-teaching semester that attempted to get children to compare solution strategies were abandoned during the last half of the semester. Also, throughout her teaching she guided children, independent

of what they were thinking, to accept particular solution strategies that she had identified. Marsha was not encouraged by the on-site teacher educator to investigate in detail what children were thinking. Indeed, as Marsha indicated in an interview near the end of student teaching, she taught CGI-type lessons "only on days when a lesson was going to be videotaped...the rest of time [they went] by the textbook." This choice seemed to be made by the on-site teacher educator.

It appears that by the conclusion of the preservice program, Marsha was in transition between Levels 1 and 2 of the Teachers' Level of Development framework (Loef & Fennema, 1992). However, her willingness to ask students questions and to create an environment in which children can give wrong answers and begin to explain their reasoning for problem solutions, may provide a base from which Marsha can progress to develop into a CGI teacher.

Discussion

The following discussion is divided into three sections: group differences, case-studies, and implications.

Group Differences

Clearly, the preservice teachers in both cohorts changed beliefs to a more constructivist orientation to teaching mathematics during their professional program of study. Based on the results of this study, it seems reasonable to conclude that beginning teachers <u>can</u> develop views of instruction that are different than "telling." However, differences existed in the amount of change that occurred within each group of preservice teachers.

Differences between the two groups of undergraduates during the first two administrations of the Beliefs Scale may have been due to variations in field experiences and the format and procedures of the internship seminars. In both cohorts, however, the greatest change in beliefs occurred during the semester in which the mathematics methods course was taught. This suggests that dealing explicitly with mathematics pedagogy does influence preservice teachers' thinking about teaching and learning mathematics. The beliefs of the CGI cohort, however, continued to change fairly dramatically during the student teaching semester while the beliefs of the non-CGI cohort did not. We argue that the base of knowledge provided by the CGI instruction was the catalyst for this continued change.

The CGI preservice teachers seemed to put more emphasis on having students figure out mathematics concepts in meaningful ways, while the non-CGI preservice teachers seemed to want students to come to reflect the mathematical understanding of the teacher. That is, CGI seemed to provide a context in which having students figure out mathematics was valued, while without that CGI base, the "game" of mathematics instruction was to have the students figure out what the teacher wanted them to say and do. The outlook of the CGI preservice teachers, then, seems much more consistent with the thrust of the mathematics education reform movement.

Case-Studies

Students can develop fragile mathematics knowledge that produces correct answers in some contexts but does not transfer to other contexts. Similarly, preservice teachers can develop fragile knowledge about teaching that may produce CGI-like behavior in some contexts but does not transfer to all teaching contexts. Preservice teachers may acknowledge the tenets of CGI and yet be unable to "pull it off" in all of their teaching. We wonder, for

example, whether the level of mathematical understanding about a topic might impact the amount of application of CGI in instruction, though there are also other forces (e.g., the intensity of beliefs) that might play a role.

CGI beliefs are manifested by each teacher in the ways that instruction is carried out in the classroom. Considerable reflection on both one's beliefs and behavior would seem to be necessary in order for consistency to develop. Short reflective journal entries may not be adequate; other contexts for reflection may be necessary (e.g., debriefings after classroom observations by an outsider, meetings with peers to discuss the progress of CGI implementation). It is not clear whether preservice teacher education programs could structurally accommodate the needed "reflection events."

Implications

The primary implication for teacher preparation is that it does seem possible to change beliefs and perceptions about mathematics instruction during a two-year undergraduate teacher certification program, though we cannot be sure whether the changes are fundamental or superficial. However, the data suggest the possibility that intensity of experience and a focus on children's thinking in the mathematics methods course may be keys for helping preservice teachers change their views. Programs of minimal duration and with minimal attention given to focusing on the needs of children may not be as successful in assisting these changes in perceptions. Teacher certification programs must acknowledge preservice teachers' beliefs and identify ways to change those beliefs so that they are more consistent with the thrust of the current reform in mathematics education.

What appears to have happened in our program is that preservice teachers began to seriously consider the use of CGI in particular and constructivism in general as a framework for their teaching. These are not the teachers that Thompson (1992) seeks who already adhere to constructivism, but they may have a firm enough footing to someday grow into her vision. We argue that CGI provides a context within which constructivism can begin to take root and that without CGI, preservice teachers do not seem as able to develop their belief systems once the support of university courses is removed. If future studies support this view, the we will have a strong rationale for inclusion of CGI in preservice teacher-education programs.

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Table 1.

Means and Standard Deviations on the Teacher Beliefs Scale for CGI and Non-CGI Undergraduate Cohorts.

		Role of the Learner		Skills and Understanding		Sequencing of Topics		Role of the Teacher	
Administration	N	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
August 1991									
CGI	32	3.04	0.43	3.07	0.39	3.28	0.39	3.21	0.41
Non-CGI	28	3.05	0.54	3.15	0.48	3.34	0.36	3.39	0.39
August 1992									
CGI	34	2.98	0.50	3.16*	0.43	3.36**	0.58	3.30	0.40
Non-CGI	28	3.20	0.62	3.42*	0.43	3.68**	0.58	3.53	0.57
January 1993									
CGI	34	3.51	0.56	3.73	0.55	3.78	0.50	3.84	0.52
Non-CGI	14	3.68	0.43	3.70	0.47	4.03	0.26	3.90	0.28
May 1993									
CGI	34	3.74	0.48	4.00	0.62	4.05	0.42	4.07	0.44
Non-CGI	20	3.72	0.63	3.89	0.51	4.01	0.40	3.92	0.34

* $p<.01$
** $p<.01$

Table 2.

Cindy's and Marsha's Belief Scores Across Subscales, By Administration.

Administration	Role of Learner	Skills and Understanding	Sequence of Topics	Role of Teacher	Overall Beliefs
Cindy					
August 1991	35	37	45	46	163
August 1992	36	42	45	47	170
January 1993	48	52	49	49	198
May 1993	47	58	56	49	210
Marsha					
August 1991	30	34	33	31	128
August 1992	32	42	39	33	146
January 1993	51	48	55	51	205
May 1993	51	52	52	49	204

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